Administrative
Report Number 32

Autumn 1990

By

Mark Holey
Fisheries Management
Sturgeon Bay

Edited by
Kendra Nelson

Bureau of Fisheries Management
Department of Natural Resources
Madison, Wisconsin 53707

LAKE MICHIGAN LAKE TROUT ASSESSMENT PLAN

OVERVIEW

Great Lakes lake trout rehabilitation has been a major goal of U.S. and Canadian governments -- federal, state, and provincial -- since the lake trout stocks collapsed in the 1950s. Yet, most Lake Michigan lake trout restoration programs have been unsuccessful.

Native lake trout used to be abundant throughout Lake Michigan -- with shallow northern reefs and deep southern reefs historically most productive. However, by 1955, native Lake Michigan lake trout were extinct -- a result of sea lamprey predation and commercial fisheries exploitation. Numerous studies document Lake Michigan lake trout history -- including Brown et al. 1981; Eschmeyer 1955; Hile, Eschmeyer, and Lunger 1951; Smith 1968; Wells 1980; and Wells and McLain 1973.

Since the first restocking of Lake Michigan lake trout in 1965, lake trout management has evolved in Wisconsin as a major segment of WDNR's Lake Michigan fisheries management program. In 1976, the Wisconsin Department of Natural Resources stocked 277,000 Green Lake strain lake trout on the Sheboygan Reef, one of four southern, mid-lake, deepwater reefs. Not only was this among the first concentrated stockings of hatchery lake trout, it also refocussed attention on the historically productive mid-lake reefs. By 1980, the Wisconsin Department of Natural Resources was stocking even larger numbers of lake trout in the mid-lake reefs and in Clay Banks, just south of Sturgeon Bay. However, potentially high incidental catch by the commercial whitefish fishery curtailed lake trout stocking in northern Green Bay and extreme northern Lake Michigan.

THE LAKE MICHIGAN FISHERIES MANAGEMENT PLAN

In 1985, the Wisconsin Department of Natural Resources completed a Lake Michigan Fisheries Management Plan -- addressing commercial fisheries, sport fisheries, and lake trout restoration. The goal and objectives for lake trout restoration (Append. A) are:

Goal

Reestablish self-sustaining lake trout populations to allow optimum sustained sport and commercial harvests.

Objectives

1. Produce a naturally reproduced year-class of lake trout that is detectable at the yearling life stage.

    A. Manage fisheries mortality of lake trout to provide an average annual total mortality of not more than 40 percent lakewide.

    B. Develop lake trout populations in two primary rehabilitation areas that exhibit seven mature age classes and either:

        1. an October spawning density of four trout per acre of spawning reef, or

        2. an annual egg deposition of 3,000 fertilized eggs per acre of spawning reef.

2. Report on progress toward Objective 1 by 1991.

Besides WDNR's planning efforts, the Lake Michigan Lake Trout Technical Committee of the Great Lakes Fishery Commission (GLFC) developed a lakewide plan for lake trout restoration (Append. B), which was completed in 1985 and has been incorporated into WDNR's lake trout objectives.

THE LAKE MICHIGAN LAKE TROUT ASSESSMENT PLAN

To coordinate WDNR's lake trout management efforts -- among the Lake Michigan District, the Southeast District, and the Central Offices -- and to enable progress evaluations, WDNR's Lake Trout Management Team developed this Lake Michigan Lake Trout Assessment Plan. Team members were: Mark Holey, Mike Toneys, and Pat McKee from Sturgeon Bay; Jim Moore from Green Bay; Paul Schultz from Plymouth; Ron Bruch from Milwaukee; and Mike Hansen from Madison.

Lake trout restoration can be a complicated and lengthy process. The Team's first challenge was to determine an appropriate evaluation timetable, based on data from native Lake Superior and stocked Lake Michigan lake trout (Table 1).

TABLE 1. Time required for a single lake trout stocking/year-class to produce natural yearlings and spawners.

	Year	Age of Stocked Trout	Age of Progeny
Stocking of Yearlings	9	1+	
First Maturity	5	6+	
Best Egg Production	7	8+	
First Yearling Detection	7	8+	1+
Best Yearling Detection	9	10+	1+
First Natural Spawning	13	14+	6+
Best Natural Spawning	15	16+	6+

However, to produce 7 mature age groups -- as outlined in Lake Michigan Fisheries Management Plan objectives -- requires another 7 years, altogether 22 years from initial stocking, to evaluate natural reproduction. Furthermore, the timetable assumes that fishing exploitation, contaminant burden, and spawning reef quality will not be limiting factors. If any or all of these factors affect lake trout spawning, they affect -- perhaps preclude -- restoration.

Next, the Team designated and ranked Lake Michigan lake trout restoration zones. Then, they developed work plans and annual reporting schedules -- considering lake trout mortality, spawning, and early life history.

REHABILITATION AREAS

The Team divided Lake Michigan into four Lake Trout Management Zones: the Northern Zone (Washington Island to Baileys Harbor), the Clay Banks Zone (Baileys Harbor to Kewaunee), the Kewaunee-Kenosha Zone, and the Mid-Lake Reef Zone (Fig. 1). Zoning was based on historical spawning areas and on fishing exploitation levels.

THE PRIMARY ZONES

The Mid-Lake Reef Zone, which historically produced numerous lake trout, is WDNR's highest priority lake trout restoration area. Most productive of the four mid-lake reefs, Sheboygan Reef (Fig. 2) supported as many as 35 commercial spawn-fishing boats in about 1940 (Coberly and Horrall 1980). Native lake trout were caught on Sheboygan Reef as late as 1954, long after they were gone from most nearshore reefs (Eschmeyer 1955).

GLFC's Lake Michigan Lake Trout Technical Committee recommended that the entire mid-lake reef area (about 640 square miles) and also a shallow spawning reef area near Beaver Island, Michigan, be made refuges. In 1984, the Wisconsin Department of Natural Resources established a 400 square mile refuge to protect the Sheboygan and Northeast reefs, considered most productive in the mid-reef area. Refuge stocking began with 750,000 yearling lake trout -- from the Marquette domestic, the Green Lake, and the Seneca Lake strains -- in 1985 (Krueger et al. 1983).

The Clay Banks Zone is the number two priority lake trout restoration area. Since 1980, numerous lake trout have been stocked in the Clay Banks - Salona Road reef area. Exploitation is limited -- with no large mesh gillnetting south of Baileys Harbor, no chub fishing from Baileys Harbor to Kewaunee, and no lake trout sport-fishing from Sturgeon Bay to Algoma. Lake trout population density in the Clay Banks is now as high or higher than anywhere in the Great Lakes.

THE SECONDARY ZONES

The Kewaunee-Kenosha Zone is a secondary lake trout rehabilitation area. The region's sport-fishing and incidental commercial catch affects but does not preclude rehabilitation.

The Northern Zone is not a lake trout rehabilitation area. Potentially high incidental catch in the northern Door County commercial whitefish and chub fisheries precludes rehabilitation.

FIGURE 1. Lake Trout Management Zones in Wisconsin's Lake Michigan waters.

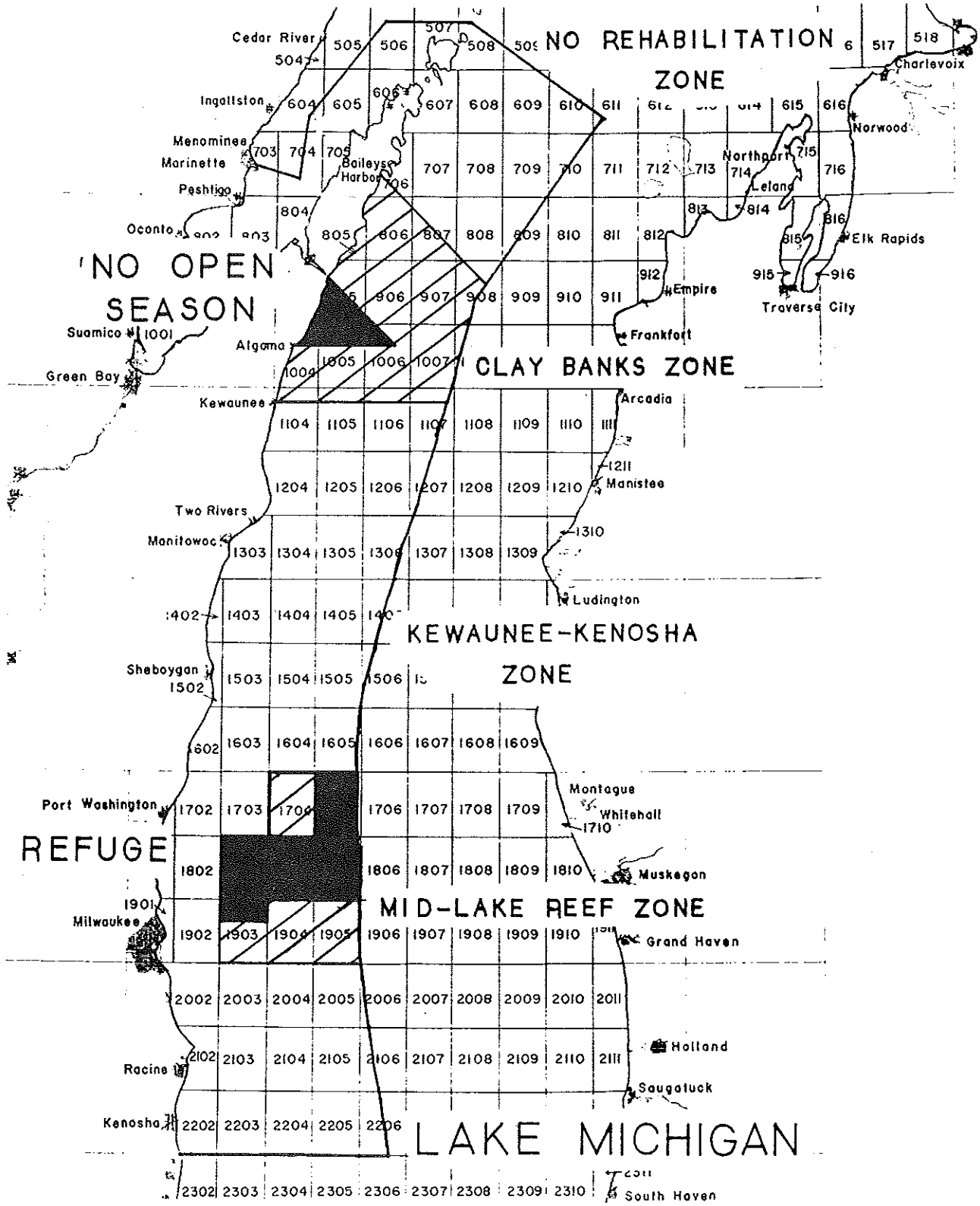
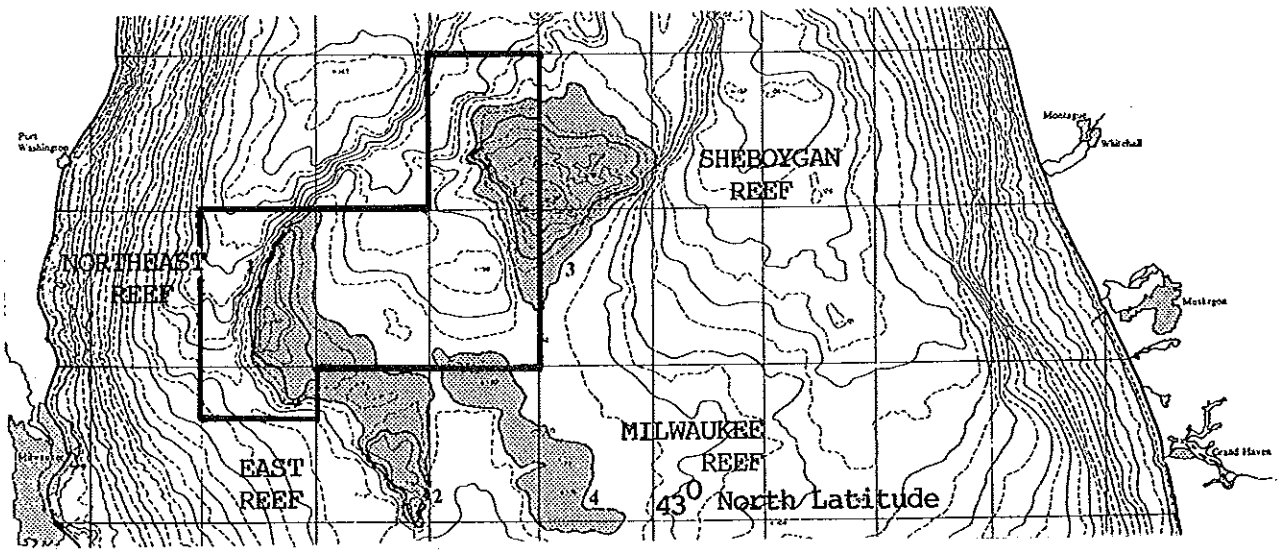


FIGURE 2. The Mid-Lake Reef Zone.



MORTALITY ASSESSMENT

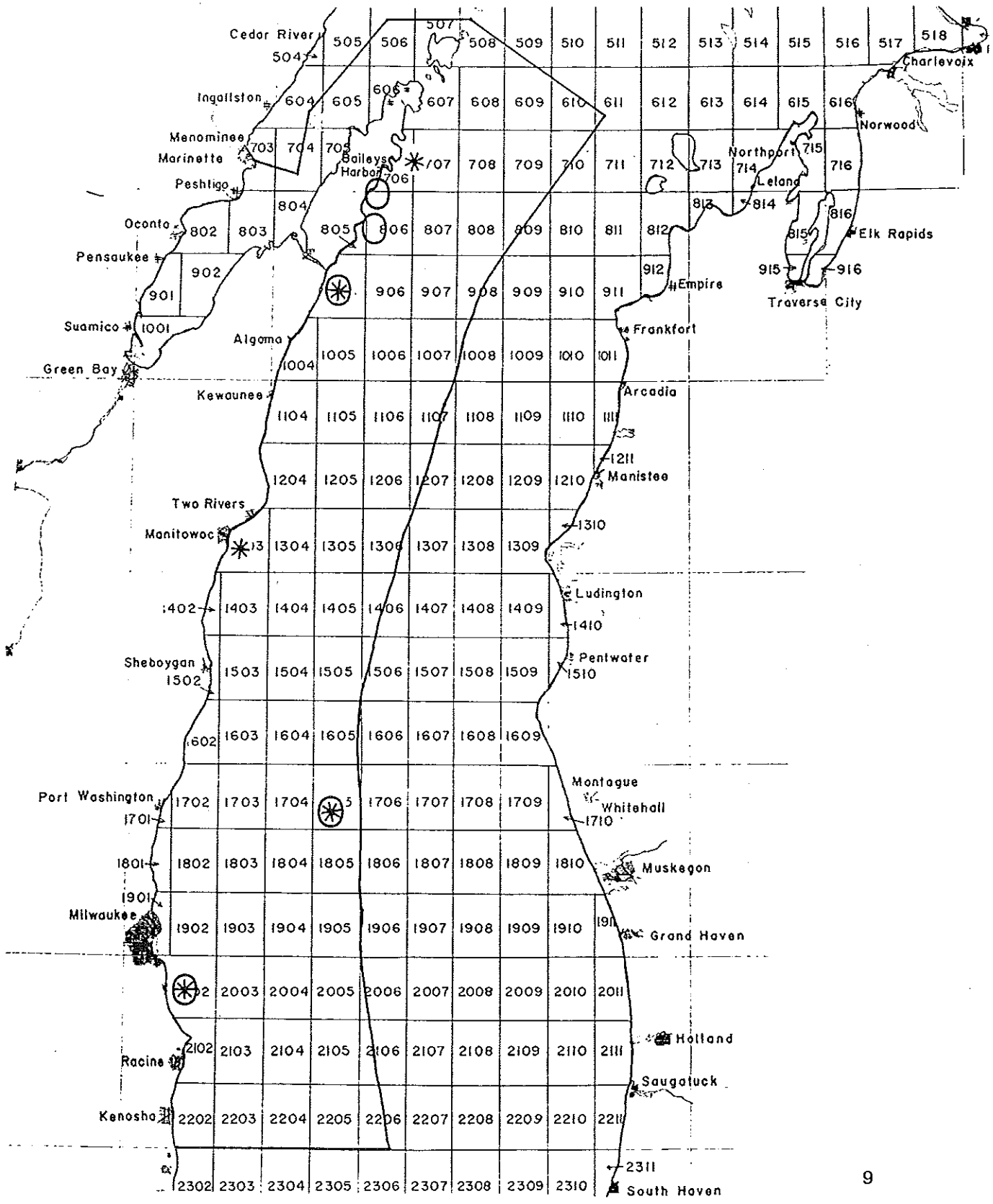
Graded mesh gillnet surveys during mid- to late-summer, sport and commercial fisheries monitoring, and spring tagging surveys will provide data to determine lake trout mortality rates and exploitation effects.

GRADED MESH GILLNET SURVEYS

Graded mesh gillnet surveys in five areas from late-July to early-September will provide lake trout population statistics. The areas will be: Cana Island, grid 706; Clay Banks, grid 905; Northein Reef, grid 1303; Sheboygan Reef, grid 1705; and South Milwaukee Reef, grid 2002 (Fig. 3). The gillnets will be multifilament nylon with 100 feet each of eight mesh sizes, ranging by half inch increments from 2 1/2- to 6-inch stretch measure.

The procedure will be: Day 1, set six 800-ft boxes of graded mesh gillnet, one each at 5-, 10-, 15-, 20-, 25-, and 30-fathoms; Day 2, lift the six boxes and reset the three that caught the most lake trout; and Days 3-5, lift and reset the three boxes. Survey crews will take weight, length, and finclip data on all lake trout caught, and scales for aging those $\geq$800 mm. Catch curves from all the lifts will be combined to determine mortality rates.

FIGURE 3. Lake trout assessment locations for mortality (✳) and spawning (O).



SPORT AND COMMERCIAL FISHERIES MONITORING

The Wisconsin Department of Natural Resources conducts annual creel surveys to monitor the harvest and age composition of lake trout in the sport fishery catch. Based on these surveys, the harvest for three areas will be reported: Kewaunee and north, Two Rivers to Sheboygan, and Port Washington to Kenosha. The catch in each area will be aged, using length and finclip data collected by the creel clerks. Total harvest by county will also be reported.

The Wisconsin Department of Natural Resources monitors Lake Michigan commercial fisheries not only to collect data on the target species (especially chub, whitefish, and perch) but also to collect data on the incidental catch of lake trout. Observing an average of more than 200 commercial lifts annually, WDNR personnel collect length, finclip, and mortality data on incidentally caught lake trout.

From the sport and commercial fisheries monitoring data, the Team will determine a lake trout catch rate, which factored with total effort will indicate total annual lake trout catch by management zone.

SPRING TAGGING SURVEYS

Tagging surveys provide data about lake trout population, survival, aging, movement, home range, homing to spawning grounds, and catch distribution. Using a 30-ft poundnet near Sturgeon Bay during late-April, May, and early-June up to 10,000 lake trout have been tagged -- with low handling mortality and high survival of the tagged lake trout. Even without tagging, catch curves will be developed from the lake trout caught to estimate mortality.

Using the 30-ft poundnet to annually tag about 5,000 lake trout just south of the Sturgeon Bay ship canal will provide data on Clay Banks lake trout. The Team also recommends using entrapment gear (a trapnet, if a poundnet is not available) for a tagging survey near the South Milwaukee Reef in southern Lake Michigan. Survey crews should take length, finclip, and tag number data on all netted lake trout, and scales for aging those $\geq$800 mm.

SPAWNING ASSESSMENT

Fall gillnet surveys of spawning reefs will provide data on spawning populations and degree of homing. Different lake trout strains will be stocked to determine which naturally reproduce best. Bottom types of all major spawning areas will be mapped.

SPAWNING SURVEYS

Graded mesh gillnet surveys will occur from mid-October through mid-November in five spawning areas: Jacksonport Reef, grid 806; Whitefish Point Reef, grid 805; Clay Banks - Salona Road, grid 905; Sheboygan Reef, grid 1705; and South Milwaukee Reef, grid 2002. Netting schedules will vary with spawning year-to-year. Survey crews will take weight, length, finclip, sex, and gonadal condition (hard, ripe, or spent) data on all lake trout caught, and scales for aging those $\geq$800 mm. Live lake trout will be tagged.

STOCKING

The Genetics Subcommittee of GLFC's Lake Michigan Lake Trout Technical Committee prepared a plan for stocking lake trout strains in Lake Michigan (Krueger et al. 1983). The plan specifies strains that should be initially stocked in shallow and deepwater reefs and outlines procedures for developing broodstock. The Committee has adopted the plan for the Beaver Island and Mid-Lake Reefs refuges.

Shallow reef lake trout strains are: the Marquette, developed from Lake Superior lake trout; the Wyoming, developed from Lake Michigan lake trout stocked in mountain lakes of Wyoming; and the Gull Island outcross, developed from Gull Island Shoal lake trout sperm and Marquette strain eggs. Deepwater strains include: the Marquette; the Green Lake, developed from Lake Michigan lake trout stocked in Green Lake, Wisconsin; and the Seneca Lake, developed from lake trout in Seneca Lake, New York.

The Team recommends using GLFC's refuge stocking strategies in nonrefuge areas of Wisconsin's Lake Michigan waters, especially at Clay Banks. The team further recommends stocking equal numbers of the Marquette, Gull Island outcross, and Wyoming strains -- or at least using more than one strain.

Coded wire tagging 5-10% of lake trout stocked at each site outside refuges will provide strain, stocking location, and age data.

BOTTOM MAPPING

Accurate bottom mapping enables lake trout stocking over the best substrate. However, detailed substrate maps are currently available only for the Door County reefs -- Clay Banks, Jacksonport, and Whitefish Point. The Team recommends additional bottom mapping follow this priority: Sheboygan Reef, South Milwaukee Reef, and Northeim Reef.

EARLY LIFE HISTORY ASSESSMENT

Recent lake trout egg survival tests at the U.S. Fish and Wildlife Service's Great Lakes Fishery Lab ranked Lake Michigan lowest among the Great Lakes. WDNR diving surveys will provide further data on egg survival, lab experiments will evaluate contaminant effects on progeny, and assessment gear will be developed to catch juvenile lake trout.

DIVING SURVEYS

Fertilized egg survival is key to lake trout restoration and only diving surveys can reveal if fertilized eggs are surviving. During fall spawning, divers will survey egg deposits, using either vacuum pumps or egg baskets. Then, in the spring, vacuum pumps and fry traps will be used to determine egg survival.

Diving surveys will concentrate on the Clay Banks area, which has the most spawners. Other nearshore reef diving surveys will occur as time, equipment, and expertise permit. However, having divers survey the mid-lake reefs is impractical.

CONTAMINANT EFFECTS

Time series data from lab experiments will profile effects of parental contaminant body burden on lake trout progeny survival. Egg survival rates are compared with PCB, DDT, dieldrin, and toxaphene levels in the parents.

Begun in 1986, the lab work is repeated at 2-year intervals. After spawning, four parental pairs from two size ranges -- 600-650 mm and $\geq$800 mm -- (16 lake trout altogether) are tested for contaminants. Then, 90 days after hatching, the progeny are also tested for contaminants. Fry survival and eye-up percentages are compared to parental contaminant body burden to determine any correlation.

JUVENILE ASSESSMENT

The sooner native (unclipped) lake trout can be detected, the better restoration efforts can be managed. Currently, assessment gillnets do not reliably sample lake trout until age 3-5. Alternative juvenile assessment gear -- including smaller mesh gillnets, trawls, and fry nets -- is being developed.

LOGISTICS

WORK RESPONSIBILITIES

Graded Mesh Gillnet Surveys -- The Milwaukee office will summarize the South Milwaukee Reef survey. The Sturgeon Bay office will summarize the Cana Island, Clay Banks, Northeim, and mid-lake reef surveys.

Sport and Commercial Fisheries Monitoring -- The Southeast District will compile the total number of lake trout caught and the age composition of the sport harvest. Commercial fishery incidental catch data, collected by each district, will be each district's responsibility -- assembling data for key-punching and proofing the printouts from Madison. The Sturgeon Bay office will summarize data from Sheboygan and with the Milwaukee office will cover Port Washington and south.

Spring Tagging Surveys -- Each district will be responsible for the tagging surveys in its waters.

Spawning Surveys -- Each district will be responsible for the spawning surveys in its waters.

Stocking -- WDNR's representative on GLFC's Lake Michigan Lake Trout Technical Committee will implement WNDR stocking plans and report on stocking.

Bottom Mapping -- Districts will cooperatively prepare maps of the reefs being worked on, including as much detail as possible.

Diving Surveys -- Each district will be responsible for the diving surveys in its waters.

Contaminant Effects -- Sturgeon Bay is responsible for the current Clay Banks study. A similar study may be conducted on the mid-lake reefs as lake trout stocked there mature.

Juvenile Assessment -- Sturgeon Bay is primarily conducting these studies.

REPORTING SCHEDULE

District reports will be submitted to Sturgeon Bay by January 15 of each year. Sturgeon Bay will combine Mortality Assessment, Spawning Assessment, and Early Life History Assessment reports into Lake Michigan Lake Trout Assessment Plan annual reports by February 15.

APPENDIX A. Lake trout objectives, problems and tactics from the Lake Michigan Fisheries Management Plan

---

OBJECTIVE 1: PRODUCE A NATURALLY REPRODUCED YEAR-CLASS OF LAKE TROUT THAT IS DETECTABLE AT THE YEARLING LIFE STAGE.

PROBLEM 1: An insufficient number of lake trout eggs are being deposited on ideal spawning substrate.

TACTICS
* Develop an egg-taking operation or a brood stock as naturally produced lake trout begin to mature to enhance egg deposition.
* Map the spawning reefs designated for rehabilitation to identify ideal spawning substrate so that fish or egg planting can be made over the most ideal substrate.

PROBLEM 2: Knowledge of the relationship between microcontaminant levels and early-life mortality is insufficient.

TACTIC
* Monitor micro-contaminant levels in lake trout closely, and periodically describe the survivability of eggs taken from Lake Michigan fish.

PROBLEM 3: It is difficult to detect young naturally reproduced lake trout.

TACTIC
* Develop and utilize techniques for detecting naturally reproduced lake trout at an early life stage.

PROBLEM 4: Public support for the lake trout rehabilitation plan is weak.

TACTIC
* Provide regular reports to user groups to keep them informed.

SUBOBJECTIVE A: MANAGE FISHERIES MORTALITY OF LAKE TROUT TO PROVIDE AN AVERAGE ANNUAL TOTAL MORTALITY OF NOT MORE THAN 40 PERCENT LAKEWIDE.

PROBLEM 1: Too many lake trout are being removed by sport and commercial fishers to maintain a less-than-40-percent annual mortality rate.

TACTIC * Reduce lake trout removal by commercial and sport fisheries by the following options:

Commercial

-Don't stock near fishery
-Create restricted fishing areas by depth
-Require low-profile nets in shallow water
-Issue lake trout tags and close the season when lake trout are caught
-Develop gear that selects against lake trout
-Create refuge areas
-Close fisheries

Sport

-Don't stock near fishery
-Reduce bag limit
-Shorten the season
-Issue lake trout tags
-Create no-possession areas
-Create refuge areas
-Close the season
-Set a size limit
-Limit use of lake trout gear (wire lines)

PROBLEM 2: Lamprey continue to prey on lake trout and could become a major limiting factor.

TACTIC * Continue our support of the lamprey control program at the 1981-83 level or better.

PROBLEM 3: Present number of assessment surveys are inadequate to measure the mortality rate lakewide.

TACTIC * Conduct lake trout assessment surveys in representative areas lakewide in a consistent format, to collect adequate population data to determine mortality rates and spawning densities.

SUBOBJECTIVE B: DEVELOP LAKE TROUT POPULATIONS IN TWO PRIMARY REHABILITATION AREAS THAT EXHIBIT SEVEN MATURE AGE CLASSES AND EITHER:

1. AN OCTOBER SPAWNING DENSITY OF 4 TROUT PER ACRE OF SPAWNING REEF, OR

2. AN ANNUAL EGG DEPOSITION OF 3,000 FERTILIZED EGGS PER ACRE OF SPAWNING REEF.

PROBLEM 1: There are inadequate numbers of mature lake trout spawning on suitable reefs.

TACTICS

* Stock lake trout with rehabilitation as the main objective and with harvest as a secondary objective.
* Stock lake trout over ideal spawning habitat instead of from shore.
* Investigate whether stocking lake trout at earlier life stages than the yearling stage would result in better homing of those fish as adults.
* Construct an artificial spawning reef.
* Determine locations of all suitable spawning reefs.

PROBLEM 2: The strain of lake trout stocked may be inappropriate for rehabilitation in Lake Michigan.

TACTIC

* Begin to stock and evaluate the performance of the following lake trout strains as recommended by the Lake Trout Technical Committee: Lake Superior domestic, Gull Island Shoal and domestic cross, Wyoming strain, Green Lake strain, and Seneca strain.

APPENDIX B

A LAKEWIDE MANAGEMENT PLAN FOR LAKE TROUT REHABILITATION IN LAKE MICHIGAN

Prepared by

Lake Michigan Lake Trout Technical Committee

March 19, 1985

INTRODUCTION

The experimental management recommendations that constitute this plan were developed by the Lake Michigan Lake Trout Technical Committee (LTTC) and its subcommittees in response to specific charges received in March 1982 and 1983 from the Lake Michigan Committee (LMC) during the latter's Annual Meetings at Michigan City, Indiana and Milwaukee, Wisconsin. In accordance with these charges, the plan focuses on the initial, practical management tactics that can reasonably be applied over the next several years to pursue more effectively the long-range goal of a self-sustaining lake trout population, able to yield an annual harvest projected conservatively at 500-700 thousand fish weighing 2.5 million lb. (See terms of reference provided by the LMC). The plan reflects an awareness not only that difficult biological questions have yet to be answered, but also that fiscal and manpower resources available among the cooperating agencies are not unlimited for continuing, modifying, evaluating, and supplementing the various management activities that comprise the rehabilitation effort on Lake Michigan.

Although the long-range goal above may not be attainable until well into the "approaching century," important interim objectives should be met in the following sequence, once the plan is implemented. Within 10 years of fully utilizing a stocking protocol that emphasizes planting young lake trout in refuges and high priority rehabilitation areas, over the most suitable spawning grounds, and with concurrent controls on sea lamprey populations and exploitation by the several fisheries, achieve larger spawning populations subject to no more than 40% total annual mortality. Within 15 years of implementing the above initiatives, be able to demonstrate routinely in trawl and gillnet surveys the presence of lake produced young of several year classes in refuges and high priority rehabilitation areas. Within 20 years, show that spawning stocks of hatchery origin are being augmented by significant numbers of wild spawners and that the abundance of wild recruits is accelerating toward a level that will eliminate the need for stocking.

For quick reference and to facilitate an orderly flow of ideas, the management recommendations themselves are presented in outline format below; the numerical sequence is not intended, however, to denote the relative importance of any item or its priority as to time of implementation. Sea lamprey predation and chemical contamination--environmental perturbations that may fundamentally affect rehabilitation and are amenable to surveillance--are covered first, followed by recommendations related to the basic need to provide the rehabilitation program with a viable hatchery product keyed to fitness in the lake. Zoning regulations and other restrictions to control exploitation, which follow, receive special emphasis, especially with reference to the intensified stocking of yearling lake trout, integrated with experiments to evaluate the performance of different strains. Site-specific experiments on the planting of various early life stages are then presented; and assessment needs in general are treated at the end.

APPENDIX B CONTINUED:

EXPERIMENTAL MANAGEMENT RECOMMENDATIONS

1.000. Maintain and supplement present environmental surveillance activities in Lake Michigan to elucidate the quality of the environment and hence its suitability for survival of stocked lake trout, their reproduction, and survival to maturity of their lake-produced young.

1.100. Continue annual monitoring of lamprey wounding rates, and whenever and wherever significant increases in lamprey attacks materialize (e.g., Pensaukee River in late 1970's), promptly notify control agents so that suspect source streams can be surveyed and control measures taken if warranted.

1.200. In cooperation with other agencies (USFWS, IJC, EPA, etc.), support continued periodic testing of lake trout for chemical contaminants suspected of adversely affecting hatchability of eggs and/or survival of fry (e.g., PCB's, toxaphene, dieldrin and chlordane).

1.300. Develop and institute a program for periodically testing lake trout eggs and fry from south, central, and northern regions of the lake for hatchability and survival of fry.

1.310. Consider conducting these tests at the experimental rearing facility for lake trout operated by Wisconsin Sea-Great at Milwaukee.

1.320. Obtain baseline information on possible regional variations in survival of early life stages of lake trout from a study conducted at the Great Lakes Fishery Laboratory (GLFL); eggs for this study were obtained from feral stocks in the vicinities of Saugatuck, Sturgeon Bay (Clay banks), and Charlevoix (Fox Islands), and from the Jordan River National Fish Hatchery (Marquette domestic strain).

2.000. Implement strategy proposed by the Genetics Subcommittee (report attached) for securing/developing, rearing, planting, and evaluating the performance of strains of lake trout with a greater theoretical potential for surviving and reproducing in Lake Michigan than those presently available.

2.100. To this end, cooperate with USFWS hatchery personnel of Regions 3, 5, and 6 in adopting ways to conserve genetic variability in hatchery brood stocks, and use strains which are possibly better preadapted for life in Lake Michigan or similar environments; eventually plant lake trout obtained directly from gametes of wild Lake Michigan populations so as to minimize undesirable domestication effects, many of which were identified at the STOCS symposium.

2.200. Provide comparative information on strain performance in Lake Michigan by marking lots of yearling lake trout of different strains with coded wire tags, planting them in large offshore refuges each year for at least five years, and estimating their respective survival and growth rates, movements, extent of lamprey wounding, and possible eventual reproductive success (see section 3.111 for additional details).

3.000. Establish special zoning regulations and related restrictions on fishing for lake trout to reduce/control exploitation so that spawning stocks of sufficient magnitude and range of age may accrue and overcome possible reproductive inefficiency of the planted fish.

3.100. Lake trout refuges: Establish two major lake trout refuges to attempt to demonstrate that if lake trout are stocked in sufficient numbers as yearlings and are provided maximum protection from fishing, they will reproduce successfully and enough lake-produced progeny will survive to maturity to generate self-sustaining populations. (The LTTC defines a major lake trout refuge as a geographical area theoretically large enough to encompass the "home range" of the species, wherein fishing for lake trout by all means and by all user groups is strictly prohibited, and no lake trout can be held in possession--except that assessment sampling by resource agencies is exempted.)

3.110. Establish Refuge I in the Fox Islands-Beaver Island area of State of Michigan waters, tentatively including all or parts of grids 313, 314, 413, 414, 415, 513, 514, 515, 516, 517, 613, and 614 (Figure 1).

3.111. For at least 5 consecutive springs beginning in 1986, experimentally plant yearling lake trout, representing a combination of equal proportions of 3 strains, on 4 historic spawning locations in Refuge I: i.e., Boulder, Gull, and Richards Reefs, and the northeast corner of South Fox Island. Mark all fish with coded-wire tags to identify lots and strains relative to rearing, release, and poststocking history. The 3 experimental strains include (1) Marquette domestic--as a control, (2) outcrosses each year between Marquette domestic females and wild Gull Island Shoal (L. Superior) males, and (3) Jenney Lake, Wyoming domestic, Lewis Lake, Wyoming wild fish, or crosses of these. (Modify these procedures during the experiment only to the extent that new findings warrant.)

3.112. Rear all lake trout to be stocked in the refuge in the same hatchery under similar conditions. Also make special efforts to plant the trout of each strain at approximately the same average size, which is considered optimal for survival at 20-25 per lb.

3.113. If present hatchery production is subsequently augmented, increase the original planting rate of roughly 1.5 yearlings per acre in Refuge I, providing that survival rates, distribution patterns, and other information indicate that higher densities are needed to overcome possible reproductive inefficiency and exploitation of the experimental fish outside the refuge, and are commensurate with carrying capacity for lake trout therein.

3.114. Consider enlarging the refuge if emigration of the planted fish is excessive.

3.120. Establish Refuge II in the mid-Lake Milwaukee-Sheboygan Reef area of State of Wisconsin and State of Michigan waters, including all or parts of 16 grids (Figure 1).

3.121. Annually stock 750 thousand or more yearling lake trout of the Marquette domestic (for reference or control) and Seneca Lake strains on 4 reefs (Northeast, East, Sheboygan, and Milwaukee) of the midlake reef complex, using the combinatorial procedure described in 3.111. Yearlings of these strains will be available for planting in Refuge II in 1985; efforts to obtain Green Lake yearlings, which were recommended earlier for this refuge, have been unsuccessful.

3.122. If hatchery production assigned to this refuge is not realized in any year, a portion of the regular annual allotment of yearling lake trout of each of the four states should be contributed for stocking therein, provided it is of the appropriate strain(s).

3.123. Also consider enlarging Refuge II if emigration of the planted fish is excessive.

3.130. Small lake trout refuges, such as the one being established by Illinois on Julian's Reef (i.e., part of grids 2403, and 2404), are endorsed in principle by LTTC, to serve as supplemental experimental sites or to reduce mortality within rehabilitation zones (3.200).

3.200. Rehabilitation zone: Except for the temporary deference of an area including Green Bay and northern reaches of the Lake Proper (3.300), declare each State's waters outside the refuges as part of a rehabilitation zone in which management efforts by the states and tribes will be directed at maintaining total mortality of adult lake trout at or below 40%.

3.210. Establish stocking priorities within the rehabilitation zone on the basis of two biological criteria: the availability of quality spawning habitat and historical lake trout production. In accordance with these criteria, establish primary and secondary management units within the rehabilitation zone as follows (see map):

Primary Unit
MM-3 (excluding refuge and deferred area below)
MM-4
MM-5
Ill. (Julian's Reef)
WM-3 (southern 2/5)
WM-4 (northern 1/5)

Secondary Unit
MM-6
MM-7 (excluding refuge)
MM-8
Ind.
Ill. (other than Julian's Reef)
WM-4 (southern 4/5)
WM-5 (excluding refuge)
WM-6

If, in turn, the individual agencies that will make the relevant management decisions cannot provide enough protection to reduce total mortality to, or maintain it at or below, the maximum of 40% in any management unit, the technical committee will recommend downgrading of the planting priority for that unit.

(Because Julian's Reef, a unique historical spawning area, located southeast of Waukegan, Illinois, has a

total area of only 1 square mile, stock about 100,000 lake trout there each year, thus providing 1 fish per acre in 156 square miles of lake immediately surrounding the reef.)

3.220. Distribute fish available for stocking on a pro rata areal basis among the primary management units (i.e., subdivisions of the rehabilitation zone) to attain a stocking density of one (1) fish per acre for waters 40 fathoms and shallower. After the desired stocking density has been attained in the primary management units, stock the secondary units at the same rate if sufficient numbers of yearlings are available.

3.300. Deferred-rehabilitation zone: Because of the uncontrollably high incidental catches of lake trout in whitefish fisheries of extreme northern Lake Michigan and Green Bay (3.200; also see Figure 1), postpone efforts to maintain total mortality of the trout at or below 40% in that area until rehabilitation is progressing in other areas. By the same token, planting of lake trout within this deferred zone for purposes of rehabilitation should also be postponed until rehabilitation is progressing elsewhere.

4.000. Conduct and/or support well-designed experiments to determine whether the planting of lake trout as eggs or fry has the potential to establish broodstocks that will home to specific areas of historic spawning reefs best suited for reproduction.

4.100. A resumption of lake trout fry planting on Horseshoe Reef in Green Bay by Wisconsin Sea Grant in cooperation with Wisconsin DNR would not confound experiments employing yearlings in refuges proposed for the lake proper. Furthermore, if evidence is found to show that lake trout planted at early life stages reach a fishable size, consideration for establishing a small refuge including and surrounding Horseshoe Reef may be warranted.

4.200. The origin of lake trout planted as fry and/or eggs after 1990 within either of the two major refuge areas recommended for yearlings (3.100) would not be distinguishable from that of the progeny of lake trout planted previously as yearlings and marked with a distinctive finclip. Eggs and fry should therefore not be planted in those areas until the method is proven to be biologically superior to the use of yearlings.

4.300. Experimental planting of early life stages on areas such as Wind Point Shoals (near Racine), for example, would perhaps be far enough removed from the major refuges (e.g., midlake reef complex) to provide alternative sites for such investigations.

4.400. Closely coordinate experiments on early life stages of lake trout in Lake Michigan with those being conducted in the Apostle Islands area of Lake Superior (Wisconsin DNR) and in northern Lake Huron (Michigan DNR). Because of different ecological conditions and logistics, some questions may be more amenable to investigation in one lake than in others.

5.000. Assure that once each of these proposed experimental initiatives is implemented, its interim results and outcome are adequately assessed by one or more agencies as needed. Specific assessment responsibilities should be assigned on the basis of each agency's resources, capabilities and commitments. The LTTC can assist by recommending candidate agencies for specific tasks, coordinating assessment effort, and technically evaluating the adequacies of sampling programs.

5.100. Chemical contaminants and sea lamprey wounding rates: Special monitoring and other assessment activities required to evaluate the effects of chemical contaminants were discussed in Section 1.000. In addition note that monitoring of sea lamprey wounding rates would generally be an integral part of any assessment yielding samples of adult lake trout.

5.200. Refuges: A special report (Appendix) on sampling methods and procedures needed to assess effectiveness of the lake trout refuges was prepared by the Assessment and Evaluation Subcommittee appointed by LTTC in July 1983. That report was reviewed and accepted in principle by LTTC in February 1984.

5.300. Monitoring fisheries: As a basis for regulating and controlling fishing for lake trout within the rehabilitation zone, provide the means for estimating the annual catch (both targeted and untargeted) by all user groups, year-class composition of the catch, and attendant vital statistics of the lake trout population. This information is essential for management aimed at holding total mortality at or below the recommended 40% level.

SPECIAL CONSIDERATIONS

This plan reflects the views of the LTTC and many other members of the management and research community in general that the collective effects of a number of possible limiting factors stand in the way of attaining self-sustaining lake trout populations in Lake Michigan. The problem of reaching that goal is therefore potentially complex, and its component parts cannot easily be identified and separated for conclusive hypothesis testing in the field and laboratory. In fact, a certain amount of experimentation involving trial-and-error, feedback, and possible procedural readjustment is necessary and implicit in the proposed management initiatives above.

It is now well established in the literature and from modeling exercises, however, that self-sustaining lake trout populations cannot be maintained if their total annual mortality in the exploited phase is higher than a value within the range of 40-50%. In contrast, the present hatchery-generated stocks in Lake Michigan may require even lower mortality if they are to maintain themselves because they are suspected of being reproductively less efficient due to possible environmental or genetically-induced deficiencies. Allowance for these stocks to increase both in number and age-spread in most areas of the lake is therefore quite clearly a minimal requirement for their rehabilitation. If the hatchery-generated adult stock does not reproduce successfully after being upgraded in number and age, even greater emphasis will have to be placed on identifying the other factor or factors that are responsible for the failure and hence for impeding restoration of self-sustaining populations.

Among the other factors that have been considered, chemical contamination is now viewed by some as potentially the most threatening. Lake trout tissue samples analyzed at GLFL contained 167 tentatively identified organic compounds, next to the highest number found in samples of either that species or walleye from the five Great Lakes and Lake St. Clair. (Lake St. Clair walleye ranked first with 215 compounds tentatively identified). It may be more than coincidental, then, that fry hatched from eggs of feral Lake Michigan lake trout have the poorest survival among all those that have been tested from the Great Lakes to date. To cover the possibility of a cause and effect relation between contaminant burdens and mortality of lake trout fry, resource managers should seriously consider "replicating" some of the above experimental management initiatives in a lake with higher water quality to provide some degree of experimental control (e.g., one or two major refuges in northern and/or central Lake Huron).

REFERENCES

Brown, Edward H. Jr., 1981. A background discussion of the Lake Michigan Committee's goal for lake trout rehabilitation: report for the Lake Michigan Lake Trout Technical Committee. Presented at Annual Meeting of Lake Michigan Committee (GLFC), Milwaukee, Wisconsin, March 11.

Great Lakes Fishery Commission (GLFC). 1982. Minutes of Annual Meeting of Lake Michigan Committee, Michigan City, Indiana, March 23-24 (Prepared by Richard Hess).

Hesselberg, Robert J. 1983. Over 400 organic compounds tentatively identified in Great Lakes Fishes. U.S. Fish and Wildlife Service, Research Information Bulletin No. 83-44.

Hynes, J. D., E. H. Brown, Jr., J. H. Helle, N. Ryman, and D. A. Webster. 1981. Guidelines for the culture of fish stocks for resource management. Can. J. Fish. Aquat. Sci. 38:1867-1876.

Krueger, Charles C., Ross M. Horrall, and Henn Gruenthal. 1983 (2nd draft). Strategy for the use of lake trout strains in Lake Michigan: genetics segment of the lake trout rehabilitation plan for Lake Michigan. Report of the Genetics Subcommittee of the Lake Michigan Lake Trout Technical Committee, Lake Michigan Committee (GLFC).

Mac, Michael J. and Carol Cotant Edsall. 1983. High mortality of fry hatched from eggs of southeastern Lake Michigan lake trout. U.S. Fish and Wildlife Service, Research Information Bulletin No. 83-43.

Pellett, Thomas D. and Michael L. Toneys. 1982. Incidental catch and total annual mortality rates for lake trout (Salvelinus mamaycush) in selected waters of Northern Lake Michigan. Wisconsin Department of Natural Resources, Bureau of Fisheries, admin. report.

Schneider, Cliff, Dianne Kolenosky and David Goldthwaite. Final Draft. A joint plan for the rehabilitation of lake trout in Lake Ontario. Lake Trout Subcommittee of the Lake Ontario Committee (GLFC).

LAKE MICHIGAN LAKE TROUT TECHNICAL COMMITTEE

Rich Hess - Illinois Dept. of Conservation
Bob Koch - Indiana Dept. of Natural Resources
Myrl Keller - Michigan Dept. of Natural Resources
Bill Eger - Tribal Biological Services and Assessment Program
Ross Horrall - University of Wisconsin - Madison
Ed Brown (Chairman) - U.S. Fish and Wildlife Service
Gary Eck - U.S. Fish and Wildlife Service
Tex Wells - U.S. Fish and Wildlife Service
Jim Moore - Wisconsin Dept. of Natural Resources
Randy Eshenroder (Liaison) - Great Lakes Fishery Commission

Genetics Subcommittee

Chuck Krueger (Chairman) - Cornell University, Ithaca
Ross Horrall - University of Wisconsin - Madison
Henn Gruenthal - U.S. Fish and Wildlife Service

Assessment and Evaluation Subcommittee

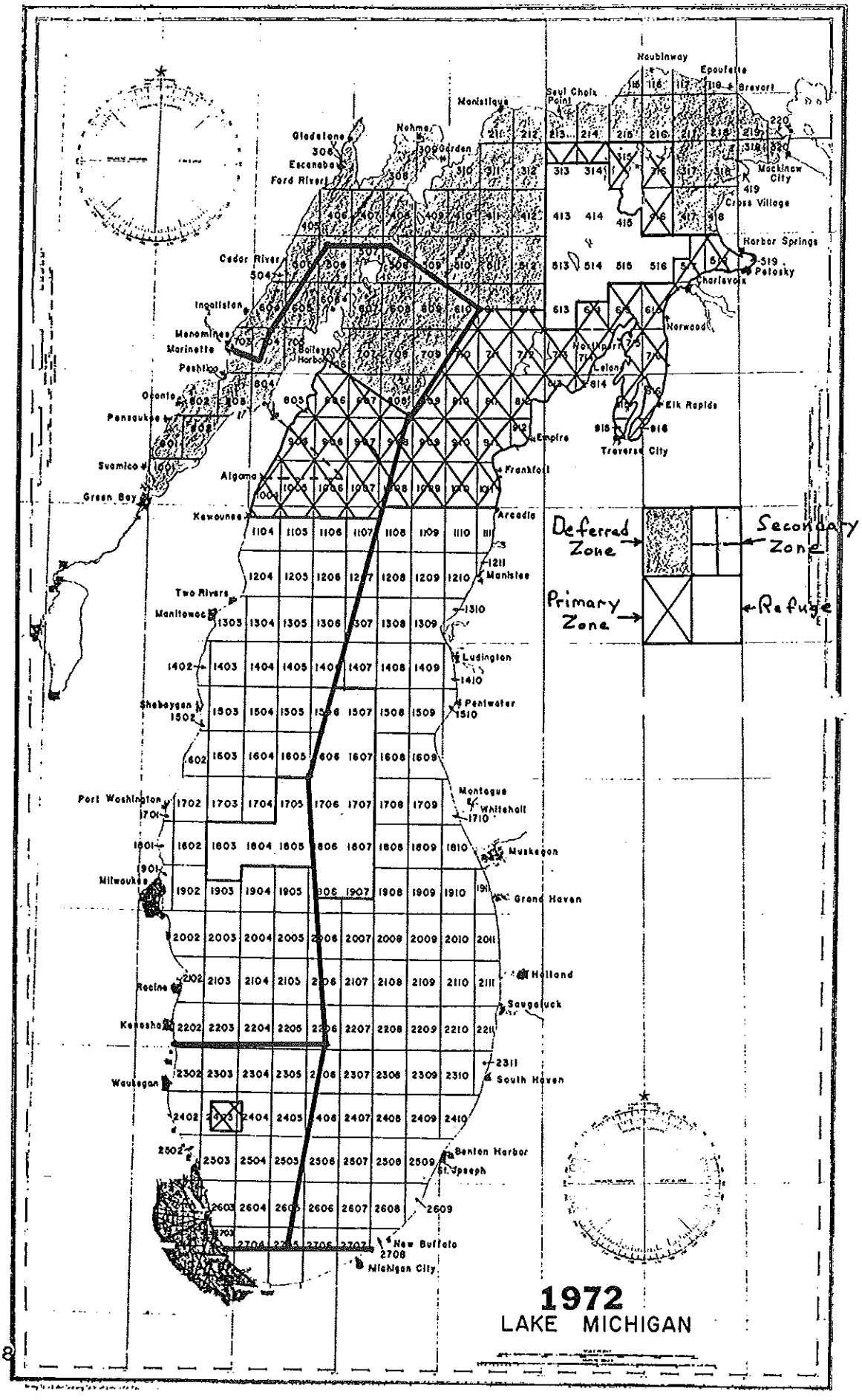
Rich Hess - Illinois Dept. of Conservation
Bob Koch - Indiana Dept. of Natural Resources
Ron Rybicki - Michigan Dept. of Natural Resources
Gary Eck (Chairman) - U.S. Fish and Wildlife Service
Mark Holey - Wisconsin Dept. of Natural Resources
Jim Moore - Wisconsin Dept. of Natural Resources

Off-Refuge Stocking Subcommittee

Rich Hess - Illinois Dept. of Conservation
Bob Koch - Indiana Dept. of Natural Resources
Myrl Keller - Michigan Dept. of Natural Resources
Bill Eger - Tribal Biological Services and Assessment Program
Ross Horrall (Chairman) - University of Wisconsin - Madison
Jim Moore - Wisconsin Dept. of Natural Resources

APPENDIX B CONTINUED:

FIGURE 1. Lake Trout Zones



*U.S. GOVERNMENT PRINTING OFFICE:1939-666-501

APPENDIX B CONTINUED:

ASSESSMENT AND EVALUATION PLAN

FOR

THE LAKE MICHIGAN LAKE TROUT REHABILITATION PLAN

Prepared by the Assessment and Evaluation Subcommittee

of the Lake Michigan Lake Trout Technical Committee (LTTC)

March 1985

Introduction

An evaluation of the progress being made following implementation of the Lake Michigan Lake Trout Rehabilitation Plan requires credible information of three distinct types: (1) measures of the biological performances of planted and naturally produced lake trout; (2) estimates of mortalities imposed on lake trout by sport and commercial fisheries through direct withdrawals and through injury by fishing gear when by-catches of lake trout are returned to water; and (3) evidence showing that fishing regulations designed to meet short- and long-term rehabilitation goals are adequately enforced. In recognition of these information needs, this plan contains sections on assessment, monitoring, and enforcement, with each section comprising a cooperative, inter-agency approach for collecting and evaluating information within its respective subject area.

Assessment Plan

This plan addresses the lake trout refuges and rehabilitation zone and the planting of lake trout therein that LTTC has proposed for Lake Michigan, identifies the types of sampling required to evaluate the lake trout rehabilitation plan, and lists the methodologies that each type of sampling will require. This plan also matches the following research and management agencies with major assessment responsibilities, in accordance with each agency's expressed interests: Illinois Department of Conservation (IDC), Indiana Department of Natural Resources (IDNR), Michigan Department of Natural Resources (MDNR), Wisconsin Department of Natural Resources (WDNR), and U.S. Fish and Wildlife Service (FWS). In addition, the Tribal Biological Services and Assessment Program has volunteered man-power assistance for certain assessment activities if needed.

1.00. Basic assessment needs and activities.

1.10. Data requirements. Data on lake trout growth, age composition, survival, percentage of natural recruitment, and geographic distribution compose a nexus of information needed to evaluate and compare the performance of lake trout within and among the various geographic subdivisions of Lake Michigan. These are minimum data needs, however, and information on relative survival, depth distributions, temperature preferences, food habits, sea lamprey scarring and wounding rates, and effects of cultural history and stocking delivery systems is also needed for comparing the performance of several genetic strains of lake trout as well as for monitoring and reporting purposes.

1.20. Sampling methodologies. Lake trout will be sampled with bottom trawls and gill nets at a net-work of existing sampling stations complemented with additional stations needed to provide more complete geographic coverage. Sampling at the additional

stations will commence when warranted by lake trout planting schedules and by the effects of growth and maturity rates on availability. The trawls will be used to sample lake trout less than or equal to age III and gill nets will be used for those greater than age III, in accordance with age-specific differences in vulnerability to these gears. MDNR and FWS are the only agencies operating on Lake Michigan that are currently equipped for fishing trawls, but because trawl designs used by the two agencies differ somewhat, a special study is needed to calibrate fishing efficiency of one gear relative to the other. Standard gangs of gill nets will consist of equal amounts of eight mesh sizes (stretched measure) ranging from 2.5 to 6 inches, in 0.5 inch increments. The locations of trawl and gill net sampling stations listed below may change as more information becomes available. (Abbreviations in the following lists: S - spring, SU - summer, F - fall; LI - lake trout index, LS - lake trout spawning index, FI - forage fish index; TBS - to be selected.)

Trawl stations.

Location	Management Unit	Time of Year	Purpose	Agency
Saugatuck	MM-7 & 8	F	LI,FI	FWS
Benton Harbor	MM-8	F	LI,FI	FWS
Waukegan	Ill.	F	LI,FI	FWS
Port Washington	WM-5	F	LI,FI	FWS
Summer Island	MM-1 & 2	F	LI,FI	FWS
Seul Choix Pt.	MM-2 & 3	F	LI,FI	FWS
Simmons Reef	MM-3	F	LI,FI	FWS
Refuge I	MM-3	F	LI,FI	FWS, MDNR
Little Traverse Bay	MM-3	F	LI	MDNR
Outer Grand Traverse Bay	MM-4	F	LI	MDNR
Good Harbor Bay	MM-5	F	LI	MDNR
Frankfort	MM-5	F	LI,FI	FWS
Ludington	MM-6	F	LI,FI	FWS
Pentwater	MM-6	F	LI	MDNR
Refuge II	WM-5,MM-7	F	LI,FI	FWS

Gill net stations.

Location	Management Unit	Time of Year	Purpose	Agency
TBS	MM-1	TBS	LI	TBS
Seul Choix Pt.	MM-1 & 2	TBS	LI	TBS
Refuge I				
Boulder Reef	MM-3	S,F	LI,LS	MDNR
Richards Reef	MM-3	S,F	LI,LS	MDNR
Gull Island Reef	MM-3	S,F	LI,LS	MDNR
South Fox Island	MM-3	F	LS	MDNR
Irishman's Grounds	MM-3	F	LS	MDNR
Head of Beaver's	MM-3	F	LS	MDNR
Dahlia Shoal	MM-3	F	LS	MDNR
Fishermens Island	MM-3	F	LS	MDNR
Little Traverse Bay	MM-3	S	LI	MDNR
Outer Grand Traverse Bay	MM-4	S	LI	MDNR
East Arm Grand Traverse Bay	MM-4	S	LI	MDNR
West Arm Grand Traverse Bay	MM-4	S	LI	MDNR
Good Harbor Bay	MM-5	F	LI,LS	MDNR
Point Betsie	MM-5	S	LI	MDNR
Little Sable Point	MM-6	S	LI	MDNR
Saugatuck	MM-7 & 8	F	LI	FWS
Michigan City	Ind	SU,F	LI	IDNR
Waukegan	Ill	SU,F	LI	IDC
Julian's Reef	Ill	F	LS	IDC
Milwaukee	WM-5 & 6	F	LI,LS	WDNR
Wind Point	WM-5 & 6	F	LI,LS	WDNR
Refuge II				
Sheboygan Reef	WM-5	SU,F	LI,LS	WDNR
Northeast Reef	WM-5	SU,F	LI,LS	WDNR
North Heim Reef	WM-4	~~F~~ SU	LI	WDNR
Cana Island	WM-3	~~F~~ SU	LI	WDNR
Whitefish Point	WM-3	F	LS	WDNR
Jackson Port Reef	WM-3	F	LS	WDNR
Clay Banks	WM-3	SU, F	LI,LS	WDNR
Larsen's Reef	WM-1	F	LS	WDNR

1.21. Additional seasonal sampling will be conducted as needed.

1.22. Window closures of commercial fishing may be requested for short periods at certain trawling stations to free the immediate area of obstructing fishing gear.

1.23. FWS will assist MDNR and WDNR with gill net sampling in refuges as needed.

2.00. Special assessment needs and activities.

2.10. Bathymetric mapping. Bathymetric mapping of major reef and shoal areas to determine the locations and extent of various types of potential lake trout spawning substrate was initiated by FWS in Refuge I in 1984, using sidescan sonar and a submersible television camera. Preliminary information from this survey has already proven its value to LTTC, and this technology should be used to map Refuge II and selected inshore areas of Lake Michigan as quickly as the scheduled use of this equipment will permit.

2.20. Limnological surveys. These surveys should be undertaken as soon as applicable assessment methods are perfected to determine if the environmental quality of substrates on major reefs and shoals in the refuges and in selected inshore areas are adequate for incubation and hatching of lake trout eggs and survival of fry.

2.30. Early life-history studies. Agencies are encouraged to develop and perfect assessment methods needed to study the early life history of lake trout in the Great Lakes. Because of logistical and technical constraints, such studies are more conveniently pursued in nearshore areas. However, although this plan relies primarily on bottom trawling to first detect natural recruitment (detected as yearlings or possibly as young-of-the-year), early detection of the cause of any disruption in the life cycle of lake trout in the favorable environs of Refuge I is considered crucial to the success of the lake trout rehabilitation program in Lake Michigan. Therefore, early life-history studies should be undertaken in Refuge I if trawling there fails to detect natural production of young (as yearlings) by the first fully mature lake trout year class resulting from the large experimental plants.

3.00. This plan is a working document that will undoubtedly be subjected to even greater short-term modification and updating than the Lakewide Plan to which it is appended as implementations of the assessment operations progress. For this reason and to preserve the desirable quality of brevity in the Lakewide Plan, we have kept the two documents separate. [Note: Sections on fishery monitoring and law enforcement will be added.]

LITERATURE CITED

Brown, E.H., Jr., G.W. Eck, N.R. Foster, R.M. Horrall, and C.E. Coberly
1981. Historical evidence for discrete stocks of lake trout (Salvelinus namaycush) in Lake Michigan. Can. J. Fish Aquat. Sci. 38:1747-58.

Coberly, C.E. and R.M. Horrall
1980. Fish spawning grounds in Wisconsin waters of the Great Lakes. Univ. Wis. Sea Grant, Madison. 42 pp.

Eschmeyer, P.H.
1955. The near extinction of lake trout in Lake Michigan. Trans. Amer. Fish. Soc. 85:102-19.

Hile, R., P.H. Eschmeyer, and G.F. Lunger
1951. Decline of the lake trout fishery in Lake Michigan. U.S. Fish and Wildl. Serv. Fish. Bull. No. 60. Vol. 52. 95 pp.

Krueger, C.C., R.M. Horrall, and H. Gruenthal
1983. Strategy for the use of lake trout strains in Lake Michigan. Dept. of Nat. Res. Admin. Rep. No. 17. 26 pp.

Smith, S.H.
1968. Species succession and fishery exploitation in the Great Lakes. J. Fish. Res. Board Can. 25:667-93.

Wells, L.
1980. Lake trout (Salvelinus namaycush) and sea lamprey (Petromyson marinus) populations in Lake Michigan, 1971-1978. Can. J. Fish Aquat. Sci. 37(11):2047-51.

Wells, L. and A.L. McLain
1973. Lake Michigan: man's effect on native fish stocks and other biota. Great Lakes Fish Comm. Tech. Rep. 20. 55 pp.